# Adaptive Mobile Firefighting Resources: - Stochastic Dynamic Optimization of International Cooperation

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***Problem:***

**Forest fires create large economical and environmental problems in many countries.**

***Questions:***

**What are the stochastic properties of fires in different countries? Is international cooperation rational?**

***Solution:***

**Adaptive optimization can optimize international cooperation. General methods and principles have been derived.**

# Slide 1: Results

## Statistical properties of fires in different countries

Correlations of burned areas in different countries during nine years (from 2010 until 2018). The original data that were used to calculate these correlations are available in the official statistics by San-Miguel-Ayanz et al (2019).

| | Italy | France | Portugal | Spain | Finland | Germany | Latvia | Norway | Sweden |
|---|---|---|---|---|---|---|---|---|---|
| Italy | 1,000 | | | | | | | | |
| France | 0,634 | 1,000 | | | | | | | |
| Portugal | 0,657 | 0,859 | 1,000 | | | | | | |
| Spain | 0,944 | 0,464 | 0,482 | 1,000 | | | | | |
| Finland | -0,492 | -0,313 | -0,230 | -0,651 | 1,000 | | | | |
| Germany | -0,349 | -0,238 | -0,184 | -0,369 | 0,666 | 1,000 | | | |
| Latvia | -0,459 | -0,291 | -0,280 | -0,467 | 0,742 | 0,951 | 1,000 | | |
| Norway | -0,427 | -0,081 | -0,158 | -0,531 | 0,682 | 0,824 | 0,864 | 1,000 | |
| Sweden | -0,464 | -0,377 | -0,356 | -0,521 | 0,894 | 0,767 | 0,888 | 0,762 | 1,000 |

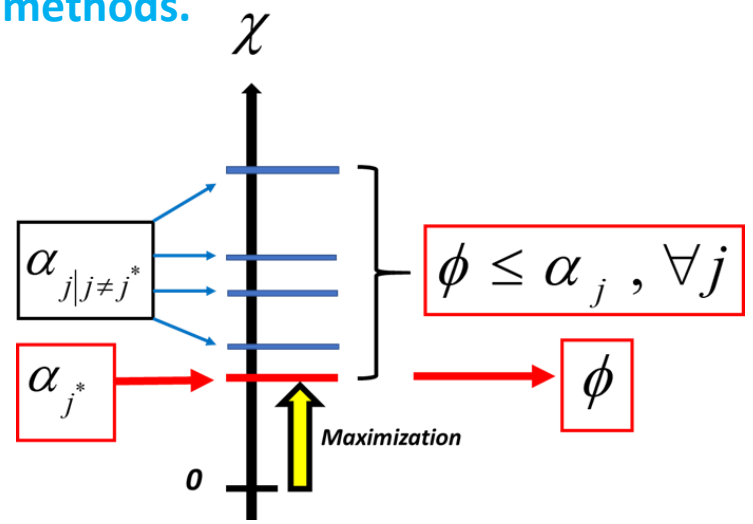
## Optimization of adaptive international fire fighting coordination via stochastic dynamic programming

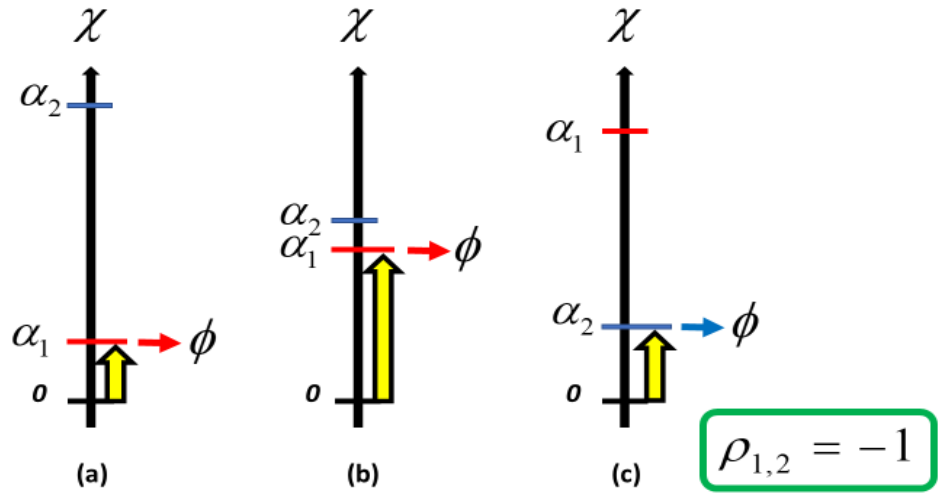
$$\phi\left(t, i_t, f_{1,t}, .., f_{n,t}\right) =$$

$$= \min_{j_t \in J_t(i_t)} \left\{ \begin{array}{l} e^{-rt} C\left(t, i_t, j_t, f_{1,t}, .., f_{n,t}\right) \\ + \sum_{f_{1,t+1}=1}^{F_{1,t+1}} \cdots \sum_{f_{n,t+1}=1}^{F_{n,t+1}} \left[ \tau\left( f_{1,t+1}, .., f_{n,t+1} \middle| t, i_t, j_t, f_{1,t}, .., f_{n,t} \right) \cdot \phi\left(t+1, i_{t+1}, f_{1,t+1}, .., f_{n,t+1}\right) \right] \end{array} \right\}$$

$$\forall t\big|_{0 \le t < T}, i_t, f_{1,t}, .., f_{n,t}$$

## Optimal solutions via analytical and numerical methods.



# Slide 2: Main Conclusions and Article

- **Statistical properties of fires in different countries and regions in nine European countries were derived.**
- **Allocation of internationally mobile firefighting units, such as water bombing airplanes, has been defined and analyzed via stochastic dynamic programming.**
- **Adaptive international cooperation in firefighting operations is rational.**

***The published open access article:***

Lohmander, P., Adaptive mobile firefighting resources, stochastic dynamic optimization of international cooperation, International Robotics & Automation Journal, Volume 6, Issue 4, 2020, pages 150-155. https://medcraveonline.com/IRATJ/IRATJ-06-00213.pdf

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**Related Research:**

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